strongly. In all our measurements the effect of age in diminishing arterial elasticity is strongly suggested; but we have not yet seen reason to believe that this is the only factor concerned.

SUMMARY AND CONCLUSIONS.

1. For diagnosis, prognosis, and treatment it is important to supplement the current methods of cardiac examination by others planned to measure the functional capacity of the cardiovascular apparatus.
2. Several such methods have recently been suggested by Germans.
3. Our experience with these methods, and especially with that of Gräupner, leads us to hope that ground has been gained in the direction of functional cardiac diagnosis.

THE TREATMENT OF ILLUMINATING GAS POISONING BY THE DIRECT TRANSFUSION OF BLOOD.

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Occurrence. At least the main toxic factor in artificial illuminating (coal) gas poisoning is carbon monoxide. Carbon monoxide constitutes 6 to 10 per cent. of illuminating gas. It occurs in the so-called "water gas" to the extent of 30 to 40 per cent. It is the important toxic constituent of the "after damp" of mines, and of the gas from charcoal and coal stoves and from blast furnaces.

Mode of Action. Its action is purely that of asphyxia. It combines with hemoglobin, displacing the oxygen. Its affinity for hemoglobin is 300 times that of oxygen. The resulting compound is not perfectly stable, so that when oxygen is present in very great excess, carbonic oxidhemoglobin will be decomposed and oxyhemoglobin formed. Hence the rational treatment of patients by oxygen inhalation.

Haldane placed animals (mice) in oxygen under a pressure of two atmospheres, so that sufficient oxygen went into simple solution in the blood serum to support life independently of the hemoglobin. Sufficient carbon monoxide was present completely to saturate their hemoglobin. Under these conditions the mice remained normal as to symptoms, showing that the carbon monoxide has no direct toxic action. When the pressure was removed and the mice put out in the air they died with symptoms of asphyxia.

Haldane claims that in recovery carbon monoxide is given off from the lungs, as such, and is not destroyed or oxidized in the body.

SYMPTOMS. To summarize: there is stimulation of the central nervous system, followed by paralysis, the order being—brain, spinal cord, medulla. To detail:

1. There is cerebral excitement.
2. There is stimulation of the medulla: (*a*) Dilatation of the cutaneous vessels with flushing. The lips are pink. If the poisoning be very acute, there may be cyanosis, due to the fact that the venous blood does not yet contain much carbon monoxide. (*b*) The blood pressure rises, due to the stimulation of the vasomotor centre. There may be ecchymoses. (*c*) The heart is first slowed, due to vagus stimulation. (*d*) Respiration is dyspnœic. (*e*) There may be vertigo, vomiting, and mydriasis.
3. Paralysis of the medullary centres follows: (*a*) The blood pressure falls, due to vasomotor paralysis. (*b*) The heart rate is increased, due to vagus paralysis. (*c*) Paralysis of respiration (cause of death).
4. Following cerebral excitement there is unconsciousness, anesthesia, and coma.
5. There are often convulsions—from below up.
6. At death the hemoglobin is usually combined with the carbon monoxide to the extent of 60 to 80 per cent.
7. In dilute solutions the blood is pink and presents a characteristic spectrum.
8. Late symptoms and after-effect: these are quite lasting in man. They may be due in part to impurities in the gas. These late symptoms are prolonged unconsciousness or mental dulness, headache, nausea, spastic condition of the limbs, and epileptiform seizures. There may be loss of memory and mental derangement for months. Pneumonia may follow.

If the patients are breathing well when rescued, the blood is probably freed from carbon monoxide in about three hours. The danger from the condition of the blood itself is probably over in an hour, that is, if there is good respiration. But when the respiration is shallow and meager, this time is, of course, much extended. The late symptoms must be due, not to the blood condition directly (for this may be normal in a few hours), but to serious and more or less lasting injury to the nervous and other tissues. Hence, any measure tending to shorten the period during which the blood is impaired will tend to prevent the late symptoms due to tissue injury.

The above statements have been largely based upon Dr. Sollman's *Pharmacology* and Haldane's article in Hale White's *Pharmacology*.

Through the kindness of Drs. A. B. Kanavel, and H. M. Richter we have received by private communication the report of 16 cases of gas poisoning, occurring in the various services of Cook County Hospital, Chicago. Statistics based on these cases may render the matter more concrete and emphasize the need of treatment beyond that hitherto practised.

Number of cases 16.

Color. Mentioned 14 times. Cherry-red, 2; flushed, 1; cyanotic, 5; pale, 1; negative, 5.

Breathing. Dyspnœa, 15; apnœa, 1 (this case was associated with morphine poisoning).

Coma, 15; mentally clear, 1.

Pupils react to light, 7 out of 11 times tested; 4 did not.

Musculature. 3 had general tetaniform convulsions; 1, muscular tremor; 2, general rigidity; 2, stiff jaws.

Pulse, ran from 96 to 200. 11 cases had as their highest pulse rate 120 to 160.

Reflexes (knee-jerks). Mentioned 12 times. Present 9 times, exaggerated once, absent twice.

Temperature. Classified according to highest reached: 98° to 99°, 1; 101° to 102°, 1; 102° to 103°, 3; 103° to 104°, 1; 104° to 105°, 1; 105° to 106°, 2; 106° to 107°, 3; 107° to 108°, 2; 109.2°, 1 case.

TREATMENT. All received the usual stimulant drugs; 10 received oxygen inhalations; 4 were bled 10, 6, 4, and 8 ounces; 5 received intravenous saline injections; and all 16 cases died.

(*a*) Artificial respiration. It is needless to give reasons for its use.

(*b*) Fresh air.

(*c*) Oxygen is certainly indicated, not to oxidize the carbon monoxide, but by being in great excess gradually to displace it.

(*d*) Heat. Many persons have collapsed on being taken into the cold air, hence, it would seem better to institute treatment in a warm room.

(*e*) Patients have often died from exertion; for example, from violent endeavor to escape from a mine. There is probably acute dilatation of the heart in these cases.

(*f*) Stimulants such as camphor, caffeine, digitalis, strychnine, etc.

(*g*) Venesection. This method is rational when combined with the injection of salt solution or blood. As to its use alone, it is condemned by most of the older writers on the ground that it further depletes a patient already in a low condition. On the other hand, Halstead reported 2 cases in which he thought it did good. Reviewing the literature, Halstead thought that no case had been saved by transfusion when venesection had failed. This was in 1884.

(*h*) Transfusion of defibrinated blood by the older methods, together with venesection. This is mainly of historical interest. The theory was that venesection rid the body of some of the poison and the transfusion would replace the lost hemoglobin with fresh hemoglobin. The basis of this procedure was the experimental work of Kühne in the 60's of the last century. In a monograph by Willy Sachs,[1] his work is summarized as follows:

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[1] Die Kohlenoxide Vergiftung, 1900.

1. Animals poisoned until eye reflex is absent recover spontaneously, provided respiration is not reduced below 2 per minute.
2. If respiration be reduced to 1 a minute, they do not recover unaided. If bled smartly they usually recover.
3. If respiration stop for a few minutes, they do not recover even though the heart is beating well, and even if they be bled and given artificial respiration.
4. Even after respiration has stopped several minutes (1 case seven minutes) when there is no peripheral pulse, no heart beat detected through the chest wall, and often with the animal in convulsions, transfusion of blood will bring back life.

There is this criticism to be offered concerning Kühne's experiments. He groups his cases largely on a basis of the rate of respiration. We have found that this is very irregular, so much so that one could never definitely say that the respiration was 2 or 1 a minute. In fact it is difficult to say when respiration has finally stopped. A large majority of the dogs stopped breathing for two or even five minutes and then began again with a fairly good quality of respiration. So we think that many of Kühne's good results were due to the fact that he began his measures during this first interval of cessation of respiration; and his dogs were not nearly so dead as he thought.

On the basis of these experiments, clinical cases of gas poisoning were transfused. This was in the 70's and 80's. Favorable cases were reported by Utuhart, Badt, Bouveret, Lühe, Rüdinger, Kahler, and Leyden. To mention a few instances, Von Heuter (1870) had a patient who was unconscious and upon whom artificial respiration had to be maintained. 500 c.c. of defibrinated blood were transfused. The patient regained consciousness in a few hours and recovered.

Leyden had a patient found in coma at 5 A.M. Venesection and artificial respiration brought no improvement. At 11.15 A.M. he had no corneal reflex; respiration was slow, irregular, and shallow; pulse bad. At 1 P.M. 250 c.c. of defibrinated human blood was transfused. At 6 P.M. he turned over in bed. At 4 A.M. he wakened, drank milk, and went on to complete recovery.

Friedberg, while he reported 3 unfavorable cases, still favored transfusion. He thought its failure due either to insufficient and poor blood, or to great injury to the nutrition of the respiratory and circulatory systems.

Albert mentions 2 cases. One had re-acted to none of the usual stimulants; heart was barely perceptible. Was transfused, recovered and could stand the next day. Another case of seemingly the same degree of intoxication was not transfused. This patient was three days unconscious. He finally lived but had the late symptoms, nervous trouble, for a month. Albert, therefore, favored transfusion.

Opposed to these favorable views were such men as Hunter and von Bergman, who thought that the danger of thrombosis and embolism outweighed any advantage that transfusion might have. Among pharmacologists, Kobert favored and Kunkle opposed transfusion on the same grounds.

(*i*) Refusion of blood. Halstead, in 1884, recorded a case treated by this method. Patient was comatose, respiration 28, shallow, pulse, 96, small, easily compressible. There was general rigidity. 512 c.c. of blood was withdrawn from the right radial artery, defibrinated and strained. 288 c.c. was reinfused centripetally into the artery. The patient made a good recovery.

(*j*) Saline intravenous infusion. In the 80's the transfusion of blood was forsaken and everyone turned to the new physiological saline solution. We have found the following recorded:

I. Jersey[2] reported a patient in collapse for twenty-four hours. Was bled 8 ounces and given 11 ounces of salt solution intravenously. Patient recovered.

II. Wilkie[3] reported 2 cases.

1. Bled 13 ounces; solt solution 13 ounces; recovery.
2. Bled 6 ounces; salt solution 13 ounces; death. Marked temporary improvement.

III. Schruber reports a patient unconscious and in convulsions on the second day. Eleven and one-half hours after having been given saline infusion he began to speak and finally recovered.

IV. Von Gordon reports 3 cases:

1. Patient unconscious, slow stertorous breathing, pulse weak and irregular, 72, reflexes lost. Bled 300 c.c.; saline 400 c.c.; recovered.
2. Patient unconscious, respiration irregular, pulse dicrotic, irregular, 120. Convulsions. Bled 300 c.c.; salt solution 300 c.c.; recovered.
3. Patient unconscious, convulsions, dyspnœa. Bled 165 c.c.; salt solution 300 c.c.; recovered.

V, VI, VII, and VIII. From Cook County Hospital cases, all terminated fatally.

Our review shows:

(*a*) The older experimental work seems faulty and insufficient.

(*b*) The clinical evidence is variable but, on the whole, leads one to have hope that the newer method of transfusion of blood will be of considerable value in these cases.

Our own research was instituted to test the value of the various therapeutic measures suggested, especially blood transfusion. Dogs were used. Ether was the anesthetic. Various forms of apparatus were used. The last one used was a large, air-tight, iron tube, into which gas and air entered through water bottles, by the bubbling of which one could make a rough guess as to the amount entering. No attempt was made to determine the exact proportion of gas in

[2] Cited by Bull. New York Med. Record, 1884.

[3] Ibid.

the mixture. It was decided, owing to the varying susceptibility of the animals, that the best basis for comparison of therapeutic measures would not be the percentage of gas, its quantity, or its time of action (that is within narrow limits), but rather the exact condition of the animal as determined according to ordinary clinical means, and especially by a manometric tracing of the blood pressure. Consequently, the carotid artery was attached to a manometer with a style writing on a revolving drum, in the usual way. A tracheal cannula was inserted and connected to a T-tube. The two branches of the T-tube were connected to valves made of fingers of rubber gloves, set in small flasks. One valve opened with inspiration, the other with expiration. The valves were connected respectively with the gas tank and the outside air, so that the dog inspired the gas mixture and expired into the outside air. The dogs were thus poisoned, and when the blood pressure reached a certain low point the various therapeutic measures were instituted and their results compared.

It would require too much time to give the history of individual experiments. A few statistics of the results may be of interest.

In all cases respiration had stopped. In the 16 cases recorded the heart had stopped in 8 cases before any measures of resuscitation were taken. Immediately the heart stopped, however, these measures had to be begun. Resuscitation was never accomplished after the heart stopped for any length of time. In 6 cases the heart had almost stopped, with a blood pressure varying from 8 to 20, with an average a little under 14 mm.—certainly a low blood pressure. In 2 cases the blood pressure was 54 and 44 mm. One was saved by transfusion, the other died notwithstanding the giving of saline.

(*a*) Animals treated by bleeding, manipulation of the heart, and artificial respiration. One experiment. Died.

(*b*) Animals treated by bleeding, intravenous saline, manipulation of the heart, and artificial respiration. Three experiments; 3 died.

(*c*) Animals simply treated by manipulation of heart and artificial respiration. Two experiments; 2 died.

(*d*) Animals treated by blood transfusion, bleeding, manipulation of the heart, and artificial respiration. Ten experiments; 7 lived, 3 died.

Reduced to the low degree of blood pressure, 7 out of 10 were rescued by transfusion of blood; 6 other dogs treated by the various other methods all died.

Of cases in which the heart stopped:

1. Blood transfusion saved 3 out of 6.
2. Intravenous saline. None saved; 1 died.
3. Simple manipulation. None saved; 2 died.

Of cases in which the heart almost stopped:

1. Blood transfusion saved 4; 1 died.
2. Intravenous saline. None saved; 2 died.

These experiments include only those done while taking a blood-pressure record on the manometer, so that the exact condition of the dog could be constantly watched.

A large number of experiments have been discarded, in which no drum record was taken, because it was found that if the exact status of the dog was judged clinically, that is, by pulse rate, stethoscope, etc., the results were so variable and so far from following any rule, so different from the above results, that one was forced to the conclusion that the starting point for initiating the various therapeutic measures was not being made reasonably the same. Hence, the conclusions could not be exact enough to be of value. Instead of an experiment with exact limitations, we were simply reproducing clinical cases, as seen in the hospital.

By recoveries we mean cases in which the blood pressure comes back approximately to the point where it started and remains fairly constant for an hour or so, and in which the respiration becomes spontaneous and of good quality again and the reflexes reappear. Actual recoveries were not done because of the difficulty of maintaining asepsis with our present means, especially while taking blood pressure records with a cannula in the carotid artery.

CONCLUSIONS. 1. Blood transfusion seems to be of greater therapeutic worth than the other measures considered.

2. For the animal to recover, it is necessary to begin transfusing immediately the heart stops beating. It is not efficacious after the heart stops finally, as, for example, is adrenalin in chloroform death.

THE EXAMINATION OF THE FECES FOR OCCULT BLOOD, WITH SPECIAL REFERENCE TO THE VALUE OF THE BENZIDIN TEST.

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(From the private laboratory of Dr. John H. Musser, Philadelphia.)

SINCE Boas,[1] in 1903, directed the attention of the medical world to the significance of small hemorrhages (unrecognizable macroscopically and called by him "occult") from the gastro-intestinal tract, the study of the feces from this viewpoint has become one of the most important of the routine clinical laboratory examinations. Since time immemorial, until comparatively recent years, the finding of blood arising from the gastro-intestinal tract was a very crude procedure and limited to but one means, the sense of vision. Either the hemorrhage must have been high up and have shown itself from the mouth as bright red blood, or as so-called "coffee-ground

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[1] Deut. med. Woch., 1903, No. 47.